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REVERSIBILITY, INTELLIGENCE AND CREATIVITY IN NINE-YEAR-OLD BOYS

by

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The undersigned hereby certify that they have read and recommend to the Faculty of Graduate Studies for acceptance, a thesis entitled, "Reversibility, Intelligence and Creativity in Nine-Year-Old Boys," submitted by Kenneth G. O'Bryan in partial fulfillment of the requirements for the degree of Master of Education.

SHORTER ABSTRACT

The relationship of Piagetian reversibility to intelligence and to creativity was investigated in 85 nine-year-old Edmonton boys.

Data were collected on Piagetian, Torrance, intelligence, age and occupation variables. Factor analyses reduced the Piagetian and Torrance batteries to derived measures of reversibility and creativity respectively. These were then combined with the other variables for statistical and factor analyses.

It was found that reversibility in the sample took two uncorrelated forms--Reversibility of Classes (inversion) and Reversibility of Relations (reciprocity). Inversion appears to be related to creativity, while reciprocity is related to intelligence.

LARGER ABSTRACT

The present study investigated the relationship of Jean Piaget's concept of reversibility to intelligence and to creativity in 85 Edmonton Public School boys aged 8 years to 9 years 6 months.

Data were collected on 35 variables consisting of age, occupation rating, 15 Piagetian tasks, 14 subscores from Torrance tests of creativity and 4 intelligence measures.

The Piagetian tasks and Torrance subscores were separately factor analysed and were recombined to form measures of reversibility and creativity respectively. Subsequently, statistical and factor analyses were applied to a battery of 16 variables including the derived measures, intelligence, age and occupation.

The major findings of the study are as follows:

1. Reversibility in 9-year-old boys appears to be composed of two types -- Reversibility of Classes (inversion) and Reversibility of Relations (reciprocity).

2. Reversibility of Classes appears to be related to creativity as represented by the measures derived from the Torrance tests.

3. Reversibility of Relations is strongly linked to intelligence as defined in the study.

4. Inversion and reciprocity as forms of reversibility are not correlated among boys in the middle ages of the concrete operational stage.

It was noted that the near homogeneity of age in the sample is a limiting factor in the interpretation of the results, and it was suggested that further research might investigate the role of reversibility in the intellectual functioning of boys and girls from the early concrete operational stage to the full development of formal operations.

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CHAPTER I

INTRODUCTION

One of the fundamental problems facing the psychologist in the field of human intellect concerns the dimensionality of abilities. Many investigators have studied the nature of creativity and of intelligence, and the relationship between them, and most have asserted that the two concepts define dimensions of individual differences that vary independently of each other or are only minimally related.

Probably the most widely accepted current view of the nature of the creative process is that which sees it as a complex pattern of abilities in which fluency, flexibility, elaboration and redefinition of ideas combine with sensitivity to problems so that an unusual or original solution is produced.

Interpretations of intelligence have evolved from the early and once traditional concept of a single entity transmitted by hereditary endowment, fixed in quantity and form and largely independent of environmental factors, to a variety of models. One such model, outlined by Vernon (1950) and MacArthur (1966), incorporates a complex hierarchy of abilities, the resultant of interaction between environment and heredity. At the top of the hierarchy and accounting for more of the total variance than any other factor in the model is a general intellectual factor similar to Spearman's "g," but not solely innate.

Developmental psychologists, led perhaps by Jean Piaget, see intelligence as involving continually higher levels of organization of intellectual structures as a result of a continuing process of interaction between the organism and its environment. In Piaget's view, intelligence involves increasing generalization and internalization of strategies for coping with new and known environmental stimuli so that there is a progression from the innate schemata of the infant to the formal, abstract, highly symbolic operations of fully functioning intelligence. Inhelder and Piaget (1964) have described these operations as a continuation of actions which express certain forms of co-ordination general to all actions. The most pervasive characteristic of operations as a whole is reversibility -- a flexibility of hindsight and foresight.

A close inspection of Inhelder and Piaget's description of reversibility suggests that it may form an integral part of both dimensions of intellect under investigation in this study. It may be that reversibility is a key factor in creative thought in so far as it supplies the cognitive mechanism for flexibility in, and elaboration and redefinition of, ideas. According to Piaget, reversibility is essential for the development of formal operations, and he has stated that "reversibility is precisely what characterizes the operations of the intelligence" (Piaget, 1961).

It is the purpose of this study to investigate the role of

reversibility in the creative process and intelligence among a sample of 85 Edmonton school boys aged between 8 years and 9 years 6 months.

CHAPTER II

THEORETICAL FRAMEWORK

A. Reversibility.

Jean Piaget (1961) has claimed that reversibility is the acme in which growth of intelligence culminates. Perception, verbalization, actions, are unrecallable entities which may linger to colour subsequent actions, but once gone they are gone forever. A thought, however, can be invoked, entertained and then revoked--banished from the cognition as though it had never existed. Difficult, costly, dangerous solutions to problems can be considered and evaluated without a momentary qualm. Regardless of how "way out" an idea is, its implications may be considered without threatening the essential coherence of conceptual systems (Berlyne, 1957). Thought represents a world relatively free from centration. It is free of the limitations imposed by perception because, in Piaget's view, thinking has the property of reversibility.

Thought processes require structures which permit mobility without resulting in disequilibrium. Piaget (1961) sees such processes as free to move rapidly from one idea to another, arranging them in new combinations while preserving stable concepts of the world at large.

The "dynamic equilibrium" which Piaget attributes to thought

can perhaps best be compared with that of a lift and its counterweight. The lift can move freely up and down, and the system remains intact and in equilibrium, no matter what floor is reached. This is because of its reversibility: any movement of the lift is compensated by an equal and opposite movement of the counterweight, and it can also be nullified by an equal and opposite movement of the lift (Berlyne, 1957).

Piaget sees operational (logical) thought emerging upon the organization of a basic set, or stock, of concepts into coherent systems. This, he believes, takes place first in the period of concrete operations which occurs between the ages of seven years and eleven years (Piaget, 1961). Operations are so named because they are "internalized responses." Systems of such operations are called "groupements," whose stability depends upon the possession of five properties: closure, reversibility (inverse and reciprocal), associativity, identity, and the dual property of tautology and iteration. Supplying flexibility of hindsight and foresight is the property of reversibility which, Piaget suggests, forms the basis for understanding logical relationships. Inhelder and Piaget (1964) have written that operational reversibility arises out of the individual's flexibility in changing criteria, either because he notices some property of which he previously failed to take account, or because new elements are added to his environment. Flexibility of

foresight occurs when there is mental anticipation of a classification or connection before it is put into practice and particularly when the best classification is chosen from a number of possible alternatives without trial and error. The present author suggests that flexibility of foresight and hindsight might be regarded as the psychological correlate of reversibility, and as such may be quantifiable. This would permit an investigation of the development of operational reversibility and its role in intellectual functioning.

In Piaget's view the solution to any problem requires the possession of schemata by or through which the person involved perceives his world and constructs a symbolic representation of it. This symbolic version is considered amenable to formal, active reasoning. It is implied that the level of intelligence will depend upon the skill with which formal active reasoning is carried out.

At the level of concrete operations, and subsequently in formal operations, manipulation of schemata is seen to be a continuation of actions expressing certain forms of co-ordination general to all actions, and in time taking on an autonomy which transcends the perception, language and maturation factors through which schemata are developed. The most general characteristic of operational thought is said to be reversibility.

B. Creativity.

In its relatively long and somewhat chequered history of

investigation, the process of creativity has been defined and re-defined largely on the basis of the researcher's theoretical position regarding the nature of intellect as a whole. This has resulted in a variety of approaches ranging from formulations in terms of stimulus-response linkings, through explanations and descriptions based on psychoanalytic theory to interpretations employing mediational variables. Despite the apparently diverse and sometimes contradictory theories arising out of the various positions, it is here suggested that the majority of the definitions are linked by a common element which appears to be very similar to Piaget's concept of reversibility.

Mednick (1962) proposed a theory of originality based on associative linking of remote elements. He defined creative thinking as the formation of associative combinations characterized by remoteness of associative elements. Essentially S.R. links are required, but Mednick recognized the presence of mediational variables and suggested that the essential element in the formation of remote associations was ability to engage in "combinatorial play." This, he argued, would allow the individual to perceive unusual relationships by associating, dissociating, and reassociating elements of the problem.

"Combinatorial play" was referred to by Pribram (1964) when he suggested that creativity was closely tied to the ability to open existing categories (in the Brunerian sense) to the coding of

normally unconventional stimuli.

Bandura and Walters (1963) formulated a theory of creativity which had its basis in operant conditioning. They suggested that original behaviour in a child arose out of differential reinforcement of responses emitted in imitation of observed models. Hence deviant behaviour would be reinforced in the case of the creative individuals, resulting in ability on their part to go beyond the normal or accepted response and produce deviant and possibly original responses. However, Smith and Raygor (1956) suggested that the capacity to go beyond immediately contiguous associates depended upon cognitive controls, a position supported by the neo-behaviourists.

Osgood's mediational model of cognitive structure conceives of the creative individual as possessing a greater repertoire of associations which he is able to combine and redefine to discern relationships and meanings not apparent to the individual whose mediational scope is narrower (1957).

Bruner (1963) stressed the importance of combinatorial activity, He viewed creative behaviour as an integration of the elements of a problem on the basis of a perception of the entire problem rather than an analysis of its parts. It involves grouping activity in which components are rearranged in novel ways, thus producing effective surprise. The ability to foresee the effect of such groupings and

the subsequent ability to return to the criterion elements would appear to be a requirement for a successful, original production. Blind permutations (although they may result in a serendipitous solution) are not considered a part of the creative process since simultaneous handling of the entire problem as a unit, not as discrete elements, is required.

The psychoanalysts (Freud, 1910; Kris, 1950; Kubie, 1958; Gordon, 1961) believed that the true nature of the creative process lay in the dichotomy between orderly, regulated and rational behaviour and the disorderly functioning of the non-rational. Gordon (1961) suggested that the dominance of the non-rational and affective processes over the rational, intellectual processes resulted in originality. He stressed the importance of three types of combinatorial play in bringing about original solutions to problems. These, he suggested, were play with meanings and definitions of words, play with metaphors, and play in manipulating fundamental concepts out of context. Lack of such play results in conventional and rational approaches to problems which cause the organism to converge on the "right" answer to a problem, rather than the novel, uncommon solution.

Guilford (1960) applied factor theory to creativity and envisioned the process in terms of mental abilities which specifically involved divergent production. This divergent production was defined as the generation of information from given information so that the

emphasis is on innovation, originality, unusual synthesis or perspective. Included under the category of divergent production are factors of fluency, flexibility, originality and elaboration. He stressed the point that redefinition of content and sensitivity to problems are of considerable importance in the creative process. Redefinition, it is here suggested, may bear comparison with the concept of combinatorial play, and with Piaget's idea of fluency and flexibility of hindsight and foresight. Guilford describes redefinition as involving transformations of thought, reinterpretations, and freedom from functional fixedness.

Torrance (1963) defined creativity as the process of sensing problems or gaps in information, forming ideas or hypotheses, testing and modifying these hypotheses and communicating the results. He considered creative thinking ability not as an entity in itself, but as being made up of such patterns of ability as fluency and flexibility of ideas together with elaboration and redefinition of hypotheses. Yamamoto (1964) applied this view to the creative person, suggesting that such a one would be rich in ideas (fluency), flexible in regard to them, and would possess the ability to redefine, reorganize, and elaborate his ideas so that an original solution might be achieved.

On the basis of the relevant literature it is here proposed that the element of redefinition of hypotheses and ideas, whether termed as such or regarded as searching through remote associations,

or as combinatorial play, seems common to many theoretical positions.

Further, there appears to be a sufficient similarity between redefinition of ideas and the Inhelder/Piaget concept of reversibility to justify an investigation of the latter's role in the creative process.

C. Intelligence.

A convenient separation may be made in the multiplicity of theories of intelligence now held. On the one hand may be listed those considered under the broad heading of Factorial Theories. On the other hand, but not necessarily opposed, are the theories which see intelligence in terms of cognitive organization. While there are many disagreements and sometimes strongly opposed views within and between the theoretical groups, there again appears to be a common element, the nature of which seems not unlike the concept of reversibility.

1. Factorial Theorists.

Spearman (1927) suggested a two-factor theory of intelligence. He introduced the concept of "g" as a mathematical quantity accounting for a correlation between apparently diverse and independent abilities which he lumped together under "s" (specifics).

Thurstone (1938) was able to identify eight dimensions of intelligence which he called Primary Mental Abilities. Each of these specifics overlapped to some extent, but he produced no general factor

in his early work since he used only orthogonal rotations.

As they stood, Thurstone's P.M.A.'s represented a close similarity to the old faculty theory and this led Vernon (1950) to reject them. Feeling also that Spearman's theory was inadequate, Vernon proposed a series of group factors arising out of, but of lesser order than "g". This has lead to an hierarchical model of intellect with "g" accounting for much of the total variance, and progressively less as the movement down the hierarchy proceeds. MacArthur (1964) has suggested that the specific factors in the hierarchy are more susceptible to differential development in differing cultures due to varying emphases in training practices.

It is here proposed that the underlying "g" postulated by the hierarchical factor theorists may be something of an underlying process rather than an ability; and that it may be closely related to the concept of reversibility. Such a position would not be in conflict with factor theory since it is possible that "g" enters into and is modified somewhat in each of the specific abilities, the amount of modification being determined, as MacArthur seems to imply, by the particular environments operating upon it.

This view of "g" as a process rather than an ability is consistent with theorists who argue that intelligence is understandable in terms of cognitive organization.

2. Mediational Theorists.

Osgood (1953) suggested a neobehaviourist approach to intelligence. He noted that certain stimuli and responses could take precedence over others and argued that such selectivity indicated the presence of cognitive organization. This resulted in the structure of the individual's conceptual nervous system coming to reflect the redundancies of his environment through predictive and evocative integrations. Intelligence is seen as the ease with which integration processes are carried out.

Bruner (1957) regards intelligence as a function of the ability to assign stimuli to veridical classes in the most parsimonious manner. He implies a process of testing and rejection or acceptance of cues on the basis of their suitability for categorization. Such testing and rejection or acceptance again seems consistent with Piaget's concept of reversibility.

Piaget has thought of intelligence as the involvement of developing levels of organization of intellectual structures, again as the result of interaction between the organism and the environment. This, he suggests, results in a series of stages of intellectual development, each of which possesses its own imperfectly developed logic. The individual progresses through the stages in sequence until eventually the level of true logical intelligence is reached. This involves the organism in increasing internalization of strategies for coping with the environment, so that it progresses from the possibly

innate schemata of the infant to the levels of symbolic operations, at which stage intelligence is fully functional.

It is important to note that both preoperational schemata and fully operational schemata are present in a multiplicity of behaviour and are general in application. Reversibility, which Inhelder and Piaget emphasize is characterized by the emergence of flexibility and fluency of hindsight and foresight, is itself the most general characteristic of operations as a whole.

The concept of a "g" underlying specific abilities, or as a process easing the carrying out of integrations, or as the ability to assign stimuli to veridical classes may not represent a unity, but in view of Piaget's assertion that reversibility is "the acme of intelligence" it seems that an investigation of its role in intelligence is justifiable.

D. Creativity, Intelligence and Reversibility.

Perhaps the most widely read work on the relationships and differences between creativity and intelligence is Getzels and Jackson's Creativity and Intelligence (1962). These authors concluded that the two concepts were relatively independent, yet the evidence for their assertions does not appear, after examination, to be convincing. A study of their data reveals almost the same amount of commonality underlies the intelligence measures used as underlies the creativity tests, so that no evidence is produced to demonstrate a

psychological dimension of creativity existing apart from a psychological dimension of intelligence. Nor did their data support the existence of a single unified dimension that could be labeled "creativity" (Thorndike, 1962; Wallach and Kogan, 1965).

A study by Cline, Richards and Needham (1963) explored seven creativity measures similar to those used by Getzels and Jackson and once again found a considerable degree of relationship existing between general intelligence and creativity.

Both Torrance and Guilford have implied that "creativity" and "intelligence" are terms that appropriately label unified but different psychological dimensions of comparable generality. Here, also, an analysis of the methods used reveals a relationship between the two concepts in a positive and significant direction. In the majority of Torrance's studies the variable used was an IQ score from which age differences have been partialed out. Age was not so treated in the creativity measures. In the case of a reasonably extensive age range the effect is to underestimate the degree of relationship between the variables.

Guilford (1956, 1960) has tended toward the drawing of a broad distinction between a class of intellectual operations labelled "divergent thinking" and more static forms of thinking. The implication is that those intellective functions represented by the concept of divergent thinking are basically different from those denoted by the classical concept of general intelligence.

Thorndike's (1962) analysis of two sets of data from Guilford's results revealed three factors in the domain of general intelligence. These he labelled, "verbal comprehension," "general reasoning," and "eduction of conceptual correlates." Five factors were found in the divergent thinking domain: originality, expressional fluency, ideational fluency, word fluency and associational fluency. The average correlation between the general intelligence factors was .43 compared with .27 correlation between the divergent thinking factors. Significantly, the average of the intercorrelations between the intelligence and divergent thinking indicators was .24, which suggests that what little there was of common variance among the latter measures may be shared with measures of general intelligence.

Wallach and Kogan (1965) felt that they had demonstrated a differential domain for creativity by presenting their measures in an unstructured "playway" situation. As a result they were able to report inter-test correlation among their measures of a much higher order than that between measures of general intelligence and creativity. They did not, however, present their general intelligence tests in the same unstructured way, and the reviewer is justified in wondering whether the apparent differentiation may be a factor of method of presentation rather than separate dimensionality.

In either case it may be suggested that research evidence thus far has failed to demonstrate that creativity and intelligence vary independently of each other or are only minimally related.

Vernon has suggested that there seems to be correlation between intelligence and creativity in heterogeneous samples and that the correlation is most marked below an IQ rating of 120. He implies that above this figure there may be grounds for postulating the existence of separate and independent domains, but he is very cautious on the point and admits the likelihood of a basic relationship.

Throughout the preceding discussions of creativity and intelligence it has been variously suggested that the nature of a possible relationship between the two concepts may be akin to the Piagetian role of reversibility. Reversibility appears to enter in one guise or another into most descriptions of intelligence, and it is difficult to conceive of an original solution which did not make use of an ability to shuffle and reshuffle ideas. Whether or not reversibility represents part, all, or none of the relationship between creativity and intelligence in heterogeneous samples of individuals remains to be seen. Indeed this study seeks neither to demonstrate such a representation nor even to assert the presence of a definite relationship between the two supposed dimensions. Nevertheless, the available evidence does suggest such a relationship, consequently it is felt that an investigation of the possible role played by reversibility in creativity and intelligence may prove worthwhile.

CHAPTER III

DEFINITIONS, POSTULATES AND HYPOTHESES

DEFINITIONS

1. Reversibility:

   (a) A flexibility of hindsight and foresight, the most general characteristic of operations.

   (b) Inversion and reciprocity in groupements.

2. Inversion:

   The form of reversibility concerned with the operations of classes.

3. Reciprocity:

   The form of reversibility concerned with the operations of relations.

4. Creativity:

   A complex pattern of abilities in which fluency, flexibility, elaboration and redefinition of ideas combine with sensitivity to problems so that an unusual solution is produced. In this study it will be operationally defined as the dimension of abilities represented by the factor analysis of Torrance tests of creativity.

5. Originality:

   A complex pattern of abilities in which fluency,

flexibility, elaboration and redefinition of ideas combine with sensitivity to problems so that an unusual response is produced. It is regarded as contributing to a creative solution.

6. Intelligence:

Intellectual ability or power, the result of genetic endowment interacting with environmental experience to form an hierarchical structure of abilities.

7. General Intelligence:

The psychomathematical concept which accounts for the correlation between apparently diverse and widely different skills, manifested in the application of a general ability to the solving of a wide range of problems. For the purposes of this investigation it will be further defined as the ability measured by tests having a high loading on the first factor extracted by factor analyzing a battery of tests of intellectual ability under the Principal Axes Method.

8. Specific Intelligence:

Particular abilities peculiar to single intellectual tasks.

9. Hindsight:

Ability to change a criterion either as the result of the addition of new elements to a given

classification or of the inclusion of a previously overlooked property of the criterion.

10. Foresight:

    The mental anticipation of a classification before it is put into practice.

11. Operations:

    Internalized responses facilitating the organization of concepts into coherent systems and acting upon such systems to produce logical thought.

12. Schemata:

    Cognitive structures which have reference to a class of similar action sequences which are strong, bounded totalities in which the constituent behavioural elements are tightly interrelated.

POSTULATES

1. The relationship of creativity to intelligence is not such that the two concepts are separate and distinct dimensions. It is postulated that a relationship exists between them in the form of a general ability factor essential to each.

2. This general ability factor is similar to Piaget and Inhelder's concept of reversibility. It is referred to in hierarchical theories of intellect as "g", in

cognitive theories of intelligence as "mediational process" and in theories of creativity as "redefinition of ideas"; "fluency and flexibility"; "divergent production"; and "combinatorial play."

HYPOTHESES

On the basis of the foregoing postulates and the relevant literature the following hypotheses are suggested.

1. Creativity and Intelligence:

   (a) The scores obtained on separate measures of creativity derived from factor analysis of Torrance tests of creativity will correlate positively and significantly with those obtained on separate measures of intelligence.

   (b) There will be a positive and significant correlation of total creativity and total intelligence test scores.

2. Creativity, Reversibility and Intelligence:

   (a) Scores obtained on measures of reversibility derived from factor analysis of the batteries of Piagetian tasks will correlate positively and significantly with those obtained on the separate measures of both the creativity and intelligence tests.

(b) Total scores obtained on the reversibility measures will correlate positively and significantly with total scores on creativity and intelligence.

(c) Factor analysis of the derived measures will produce a factor defined by reversibility which will also load positively on creativity and intelligence.

CHAPTER IV

EXPERIMENTAL DESIGN

DATA COLLECTION

A. The Sample

The sample was drawn from all Canadian born boys presently enrolled in Grade III in Garneau, Queen Alexandra, and Laurier Heights elementary schools of the Edmonton Public School Board. Eighty-five subjects comprising 90% of the population of boys were tested. The full sample mean age was 8 years 6 months with a SD of 3.6 months, Total age range was 8 years 0 months to 9 years 6 months,however all but three of the boys were aged between 8 years and 8 years 10 months. Mean score on the Otis Total Alpha (S) was 65. Scores ranged from 31 to 84. Some description of the socio-economic status of the sample was obtained through use of the Canadian Occupational Scale (Blishen, 1958). Mean occupation rating was 58.3. SD was 11.6 and occupation ratings ranged between 30.0 and 82.6. Consequently the sample was considered to be heterogeneous in regard to occupational level, and socio-economic status generally. This finding was supported by reference to the Henderson directory for Edmonton which indicated that the total sample was drawn from a wide range of social status areas.

The composition of the sample is shown in Table I.

TABLE I

DESCRIPTION OF THE SAMPLE

SCHOOL	N	GR	AGE IN MONTHS			OCCUPATION			OTIS IQ		
			$\bar{X}$	SD	RANGE	$\bar{X}$	SD	RANGE	$\bar{X}$	SD	RANGE
Queen Alexandra	14	3	103	4.0	96-114	54	11.2	30-76	106	15.2	72-124
Garneau	21	3	102	3.6	96-109	56	11.8	44-72	109	14.8	85-141
Laurier Heights	50	3	102	3.4	96-108	60	11.6	41-83	110	14.9	79-135
TOTAL GROUP	85	3	102	3.6	96-114	58	11.6	30-83	109	15.0	72-141

B. The Instruments

Initially, the following tasks and tests were administered to the sample. The results obtained were later subjected to factor analysis in order to develop composite measures of creativity and reversibility for analysis with well established measures of intelligence.

Piagetian Tasks

A number of Piagetian tasks has been drawn together from three interpretations of his clinical method to form the source for variables believed related to reversibility.

TABLE II

RELIABILITIES OF THE TESTS AND TASKS

NAME	ITEMS	REPORTED RELIABILITY	TYPE OF RELIABILITY	FACTOR ANALYSIS COMMUNALITIES
Rav. Col. Prog. Mat.	36	.80-.90	Test-retest	.59
Hidden Figures	21	.66	Least est. from F.A.	.71
Otis Verbal	45	.87	Split half	.71
Otis Non verbal	45	.88	Split half	.57
Unusual Uses	4	.49-.83	Test-retest	
Fluency		.42-.85	Test-retest	.95
Flexibility		.28-.69	Test-retest	.68
Originality		.46-.77	Test-retest	.96
Elaboration		.53-.81	Test-retest	.93
Picture Completion	4			
Fluency		.65	Least est. from F.A.	.65
Flexibility		.73	Least est. from F.A.	.73
Originality		.64	Least est. from F.A.	.64
Elaboration		.55	Least est. from F.A.	.55
Picture Construction	2			
Originality		.66	Least est. from F.A.	.66
Elaboration		.69	Least est. from F.A.	.69
Circles	4	.61-.75	Test-retest	
Fluency		.63-.76	Test-retest	.83
Flexibility		.68-.63	Test-retest	.61
Originality		.58-.79	Test-retest	.91
Elaboration		.51-.69	Test-retest	.91
Vernon/Piaget*	28	.52-.55	Least est. from F.A.	.45-.83
Towler/Piaget	9	None reported	Least est. from F.A.	.59
Inhelder/Piaget	3	None reported	Least est. from F.A.	.72

*Contains subtests for which range of estimated reliability is reported.

1. Vernon's adaptation of Piagetian tasks.

Vernon (1965) has conducted a series of investigations using a number of tasks adapted from the clinical procedures of the Geneva School. As a result, some quantification has been possible in the area of conservation, number and visualization. Eleven tasks yield a total of 28 items which were administered and scored according to principles suggested by MacArthur (1964). Tests included in the battery are: Time concepts; Equi-distant counters; Logical inclusion; Visualizing water in a tilted bottle; Conservation of volume in a liquid; Conservation of volume in a solid; Visualizing an insect in differing positions; Number concepts; Conservation of length of rods; Position and size of shadow; Conservation of area.

2. Towler/Piaget Tasks.

One test was used from a battery of measures described by Towler (1965). The selected task, Natural Axes, contains nine items and yields a total possible score of 18 points, since each item has two parts.

3. Inhelder/Piaget Tasks in Flexibility in Hindsight and Foresight.

Task (a) provides for a reclassification of an existing arrangement on the basis of the addition of a new element. Three such were introduced and the subject was asked to make as many reclassifications as possible.

In task (b) all elements are presented initially, and the subject was required to produce as many reclassifications as he was able, according to the test instructions.

Task (c) requires a verbal statement from the subject of the classification he will attempt to make.

Fifteen Piagetian variables were available for analysis.

Measures of Creativity.

Four measures of creativity were used. Each is a Torrance test of creative behaviour, described by the author as suitable for children in an age range similar to the sample under study. The measures are based on the definition of creativity which appears in Chapter III, and are attempted operational definitions of the theoretical concept. Three yield 4 scores representing fluency, flexibility, originality, and elaboration of ideas while the other, Picture Construction, provides 2 scores, originality and elaboration. Marking of the tests adhered to Yamamoto's principles (1964).

The four measures employed are:

1. Unusual uses.
2. Picture completion.
3. Picture Construction.
4. Circles.

Thus 14 separate variables were available for statistical treatment.

Measures of Intelligence.

1. Raven's Coloured Progressive Matrices.

This test is suitable for use with children between 5 years and 11 years and represents an attempt to measure intellectual functioning within the context of Spearman's "g". Tasks, or matrices, consist of designs which require completion. Multiple choice options allow completion of the patterns so that a correct response may be made on the basis of

(a) completing a pattern or an analogy;

(b) systematically altering a pattern;

(c) introducing systematic permutations;

(d) systematically resolving figures into parts.

The avowed intention of the test is to measure "g," and its validity has been to some extent supported by MacArthur's research among Eskimo and Metis. "Perceptual reasoning" is supposed to be a principal factor underlying the rationale of the test.

2. Children's Hidden Figures Test.

This test is an adaptation by Vernon of Gottschaldt figures. It has a possible relation to Spearman's "g" since it appears to be relatively free of cultural contamination. Additionally, research has shown it to be effective in diagnosing field dependence, which may be a contaminating factor in the Piaget/Inhelder tests. It was considered advisable to include the Hidden Figures Test as an index of such

field dependency since subjects who do well on the test seem to have the ability to analyze a complex configuration and then respond to some parts of it and ignore others. It was used by Vernon (1965) as a group test for children.

3. Otis Quick-Scoring Mental Ability Test. Alpha Level.

The alpha level of the Otis is rated by the publisher as suitable for use in grades 1.5 to 4. It offers three scores which are labelled Verbal, Non Verbal, and Total. However, the short form provides only one IQ rating, that of the total score. Mental age versus chronological age is used to compute the IQ. MacArthur's research (1965) has suggested that the Otis is heavily affected by environmental variables. Consequently an analysis of it would be expected to yield some group factors in addition to "g". The obtained general factor would be a useful identifying source for the purpose of the factor analysis proposed in this investigation.

Measures of Socio Economic Status.

1. The Henderson Directory for Edmonton.

2. The Canadian Occupational Scale. (Blishen 1958).

Data were thus collected for the sample on 35 initial variables.

TREATMENT OF DATA.

A. Descriptive Data.

Ratings made on the basis of the Blishen Scale and the Henderson directory were used as a combined description of the representativeness

of the sample.

Blishen numbers were included as an unscaled variable measuring parental occupational status.

Age in months at the time of testing was calculated for each subject and this too constituted an unscaled variable.

B. Measurement Data.

Administration of all measures was carried out by the investigator in two stages. Hidden Figures, Raven's Coloured Progressive Matrices, Otis Verbal and Non Verbal, and all the Torrance tests were presented as group tests to every grade III class in each school. Both boys and girls were tested in class groups over a period of two weeks. Scoring was conducted in accordance with the publisher's or author's instructions. In the case of the Torrance tests a special effort was made to maintain consistent scoring procedures in that note was taken of unusual interpretations of the stimuli so that similar interpretations would be scored alike. The testing sessions were introduced in a standardized form as described in Appendix I.

All Piagetian tasks were individually administered by the investigator and the responses of the subject were scored as reported in Appendix I. Note was taken of the subject's reasons for his responses so that a check could be made on the attainment of an understanding of the concept underlying the task.

C. Statistical Analysis.

1. Introduction:

The data were recorded on IBM cards and subjected to analysis using a procedure developed by Hunka (1965). Means, standard deviations and intercorrelations of 35 variables were obtained and, of these, all but two (age and occupation) were normalized with a mean of 50 and standard deviation of 10. The variables were then separated into the three relevant to the study and both the Torrance tests and Piagetian tasks were factor analyzed as separate batteries. The purpose underlying this procedure was to draw together measures of psychological structures operating in the supposed dimensions of creativity and reversibility. This was felt to be necessary since, as Ohnmacht (1966) has pointed out, it is important to add together those measures which have common factor loadings if proposed cumulative measures of a psychological function are to be presumed legitimate.

2. Factor Analysis.

The variance of a set of obtained scores for a given test is composed of true variance which arises out of individual differences occurring between the subjects, and error variance which is the result of measurement error. Where correlation exists between a number of measures, part of the true variance will be common to at least two of the tests; additionally, each test will have some specific variance. The common variance is of prime importance to the rationale underlying factor analysis which is based on the assumption of reflection by the

intercorrelations of a common variable which the correlated tests are measuring to some extent.

While none of these tests needs be a pure measure of the hypothetical variable, it may be compared with other tests loading on the same factor. Thus the procedure of factor analysis assists in the reduction of a number of tests to a lesser number of dimensions, hypothetical variables or factors, whose magnitude and identity are a result of the configuration of common variance among the tests. If such common factors can be found, parsimony has been achieved. If meaning can then be given to the factors, some ordering of psychological thought can be derived from the domain under investigation so that new understandings of the measurement areas of, and relationships between, the tests may be gained.

(a) Principal Axis Factor Analysis.

The first method of factor analysis used in this study is the Principal Axis Factor system which gives a unique mathematical solution for a given correlation matrix and also takes out the maximum possible variance with a given number of factors.

A scattergram is obtained when the scores of the subjects taking two positively correlated tests are plotted against each other with the axes representing scales based on the test scores. When three variables are used, an ellipsoidal distribution results; n variables result in a set of N points (one per person) in an n-space (one dimension per test). The corresponding principal axes of the

ellipsoids thus formed are in the same directions and from these directions are drawn reference axes. When a transformation is performed so that the n tests are placed in an N-space where one dimension corresponds to each person, the test vectors take up positions such that the cosines of the angles between them are equal to the correlation coefficients. Factor loadings are given by the perpendicular projections of the test vectors onto the reference axes. Accordingly a factor may be summarized as a hypothetical variable common to several tests,while factor loadings are quantities which express the extent to which each individual test in a battery measures the particular factor under consideration.

The matrices of intercorrelations between tests obtained from the full sample were subjected first to the Principal Axis Factor Analysis using unities in the diagonal cells of the matrices. The computations were performed by the University of Alberta's IBM 7040 computing system. Householder's (1938) method of analysis was employed.

(b) Varimax Factor Rotation.

Harmon (1960) suggested that the fundamental reason for objective rotation is the achievement of greater ease of interpretation of the solution. In the Varimax method, emphasis is placed upon simplification of the columns of the factor matrix by maximizing the variance of the squared loadings of the factors. The "normal Varimax" solution, a method derived by Kaiser (1958) is used in this thesis. Those

principal axis factors which had an eigenvalue in excess of one were regarded as significant since they contributed more variance than did a single test (Kaiser, 1960). In order to facilitate and provide for a possible basis of interpretation, analytic rotations were carried out. Rotated factor matrices approximating simple structure were obtained, although the procedure destroys the uniqueness of the Principal Axis solution. This is to some extent compensated for by the resultant parsimony and greater ease of interpretation, which Harman (1960) suggests are more basic principles than mathematical purity.

(c) Promax Rotation to Oblique Simple Structure.

In order to further facilitate identification of the factors, the Hendrickson and White (1964) method of rotating to oblique, simple structure was employed. The Promax uses Kaiser's Varimax method to provide a least squares fit to an "ideal" oblique solution constructed from an orthogonal method of factor analysis.

The oblique solution offers advantages in the interpretation of factor coefficients as meaningful psychological constructs. Harman (1960) points out that the primary factor pattern gives the precise saturation of the factors and is thus more useful than the primary factor structure. Consequently the pattern on the primaries in conjunction with the correlations between them will be used.

The coefficients obtained are not factor "loadings" in the sense of orthogonal solutions, although Fruchter (1954) refers to them as such. According to Harman (1960) the term lacks precision of

meaning when applied to oblique solutions since it does not mean either correlation or coefficient. He prefers to use the well defined concept of correlation coefficient, and his precept has been followed in this investigation.

3. Testing of Hypotheses.

As a result of the first factor analyses the 14 Torrance variables were combined to form 4 creativity measures. The same treatment was applied to the 15 Piagetian tasks which resulted in 6 measures. Together with the 4 intelligence measures they form the battery upon which the hypotheses will be tested. A description of the formation of the measures appears in section A of Chapter V, Results.

Hypothesis 1. Creativity and Intelligence.

(a) The combined normalized scores obtained on each of the composite creativity measures were subjected to intercorrelation with each of the 4 intelligence measures and examined for significance at the .05 level of significance for one-tailed tests.

(b) The summed, normalized scores for all intelligence measures were correlated with the summed normalized scores for creativity measures and examined for significance at the .05 level for one-tailed tests,

Hypothesis 2. Creativity, Intelligence and Reversibility.

(a) The normalized scores obtained on each of the measures

of reversibility were intercorrelated with the creativity and intelligence measures and examined for significance at the ,05 level of significance for one-tailed tests.

(b) The summed normalized scores for each type of reversibility were correlated with total creativity and total intelligence and examined for significance at the .05 level for one-tailed tests.

(c) Factor analysis of Creativity, Intelligence and Reversibility. Three forms of Factor Analysis, Principal Axis, Varimax Rotation and Promax Rotation were used to examine the relationship of the supposed dimensions of creativity and intelligence to each other and to reversibility.

CHAPTER V

RESULTS

The results obtained are reported in two sections. The first part deals with the factor analysis of the original batteries of tests and tasks from which the measures of reversibility and of creativity were derived. This part also contains a brief discussion of the rationale underlying the combinations made and a description of the methods used. The second section of this chapter presents the results of the statistical and factor analyses carried out on the derived measures.

A. Derivation of the Measures.

Since much is already known of the factorial composition of the group tests of intelligence, it was decided not to combine them into measures of intelligence on the basis of factor analysis of results obtained from the present sample. They have been used as marker tests to assist in factor identification, and separate and combined tests of intelligence in the final statistical analyses. Consequently, concentration has been directed towards the results of factor analysis of the Piagetian tasks and the Torrance tests. Intercorrelation matrices upon which factor analyses were performed are presented in Appendix III.

Table III shows the loadings on the unrotated Principal Axes factors for Piagetian tasks.

TABLE III

PIAGETIAN TASKS UNROTATED PRINCIPAL AXES FACTOR LOADINGS

VARIABLES	FACTOR LOADINGS I	II	III	IV	V	VI	COMMUN-ALITY
1. Time	.085	-.163	-.213	.508	-.460	.036	.550
2. Counter	.416	.048	-.031	-.611	-.080	-.442	.752
3. Inclusion	.086	.178	.084	.119	-.681	-.551	.827
4. Tilted Bottle	.076	-.507	-.519	.289	.233	-.172	.699
5. C.V. Liquid	.368	.342	-.342	.175	-.434	-.251	.651
6. C.V. Plasticene	.471	.150	.346	.631	-.016	-.115	.776
7. Insect	.234	-.698	-.268	-.115	-.035	.131	.645
8. Number	.165	.158	.674	.169	-.248	-.303	.689
9. Cons. Length	.151	-.381	.422	-.245	-.209	.055	.452
10. Shadow	.390	-.490	.024	-.222	-.129	-.247	.520
11. Cons. Area	.399	.315	-.520	-.073	-.131	-.159	.576
12. Towler Tasks	.334	-.554	.004	-.259	-.322	.016	.589
13. Flex. H/s (a)	.709	.097	-.089	-.025	.216	.065	.571
14. Flex. H/s (b)	.587	.267	.037	-.007	.232	.433	.658
15. Flex. F/s	.810	.058	.110	-.038	.125	.171	.718
Percentage of Total Variance	17.2	12.3	10.4	9.2	8.6	6.8	64.5

Tables IV and V respectively show loadings on the Varimax rotated factors and Promax coefficients in an oblique solution. Loadings and coefficients between .30 and -.30 have been omitted. Table VI displays the correlations between the Promax primaries.

Coefficients derived from the Promax transformation were used as the principal source of evidence for the identification of the factors.

Factor I was identified as a reversibility factor type A defined by high coefficients on the Inhelder/Piaget tasks of Flexibility of Hindsight (a) (.658), Flexibility of Hindsight (b) (.854) and Flexibility of Foresight (.770). The only other task with a coefficient above .3 was Conservation of Volume in Plasticene (.309). On the orthogonal rotation this factor accounted for 22% of the common variance.

Piaget, in considering the development of groupements which express the totality of operations at the psychological level of concrete operations, writes that "these various groupements exhibit two very distinct forms of reversibility" (1957, p. 28). He names one 'Inversion,' the other 'Reciprocity,' and goes on to state:

TABLE IV

PIAGETIAN TASKS ROTATED FACTOR LOADINGS (VARIMAX)

VARIABLES	FACTOR LOADINGS I	II	III	IV	V	VI	COMMUN-ALITY
1. Time			.451		.809	-.307	.550
2. Counters							.752
3. Inclusion						.902	.827
4. Tilted Bottle		.755					.699
5. C.V. Liquid			.780				.651
6. C.V. Plasticene	.374			.714			.776
7. Insect		.663				-.335	.645
8. Number				.775			.689
9. Cons. Length			-.340		.376	-.332	.452
10. Shadow		.380			.566		.520
11. Cons. Area			.651				.567
12. Towler Tasks		.666					.589
13. Flex. H/s (a)	.695						.571
14. Flex. H/s (b)	.795						.658
15. Flex. F/s	.794						.718
Percentage of Total Variance	14.2	11.7	10.4	10.1	9.8	8.3	64.5

TABLE V

PIAGET TASKS: PROMAX PATTERN ON THE PRIMARIES

VARIABLES	FACTOR COEFFICIENTS I	II	III	IV	V	VI
1. Time			.481			
2. Counters					.937	
3. Inclusion						1.014
4. Tilted Bottle		.835				
5. C.V. Liquid			.845			
6. C.V. Plasticene	.309			.753		
7. Insect		.653				
8. Number				.820		
9. Cons. Length		.341				
10. Shadow					.533	
11. Cons. Area			.672			
12. Towler Tasks		.670				
13. Flex. H/s (a)	.658					
14. Flex. H/s (b)	.854					
15. Flex. F/s	.770					

Note: Coefficients below .30 omitted.

TABLE VI

CORRELATIONS BETWEEN PROMAX PRIMARIES
FOR PIAGETIAN TASKS

FACTOR	I	II	III	IV	V	VI
I	1.0					
II	.080	1.0				
III	.167	-.013	1.0			
IV	.130	.210	-.116	1.0		
V	.177	.163	-.277	.128	1.0	
VI	.076	-.251	.189	-.262	-.320	1.0

> "Inversion is the form of reversibility concerned with the operations of classes, and reciprocity the form concerned with the operations of relations. No groupements are present at the level of concrete operations to combine these two kinds of reversibility into a single system. From the standpoint of mental development, inversion (negation or elimination) and reciprocity (symmetry) form two kinds of reversibility, whose beginnings are already to be seen at the lower developmental levels. At the level of concrete operations, they appear in the form of two distinct operational structures (groupements of classes and groupements of relations), and finally form a unique system at the level of propositional operations." (ibid)

In view of the classification tasks involved in the Inhelder/Piaget battery, the label Reversibility A was applied to the dimension represented by Factor I. It seems possible that this factor may be reflecting the operation of inversion.

Factor II was identified as a reversibility factor type (B) defined by high coefficients on Towler Tasks (.670), Tilted bottle (.835) and Insect (.635). Only Conservation of Length had a coefficient in excess of .300. The rationale underlying the naming of this factor as an operational statement of reciprocity, or reversibility in groupements of relations, stems from several references by Piaget and Inhelder, (1953), (1958), (1963), (1964) to the necessity for a child to return to the identity operator by way of the reciprocal in tasks requiring visualization of relationships in concrete data. Since every task with substantial coefficients on this factor requires a reference to a model and construction of a response based upon the transformation of that model, it is supposed likely that this

involves considerable formal or concrete operational use of the reciprocal operator. It is suggested that more is involved in the task than visualization of the sort used in space relationship tasks of the Differential Aptitude Tests type, since the subject is actually required to transform the stimulus rather than select a transformation from a number of provided alternatives.

Factor II accounted for 18% of the common variance on the basis of the Varimax rotation. Correlation between the first and second factors was negligible at .08, so it seems likely that they are indeed separate and distinct dimensions.

Factor III showed high correlation coefficients on Conservation of Liquid (.845), Conservation of Area (.672) and Time (.481). The percentage of common variance represented by this factor was 16% (Varimax). On the basis of the content and supposed processes involved in the tasks, Factor III was identified as a Conservation of Liquid and Area factor. It had a slight positive correlation with Factor I (.167) and negligible correlation with Factor II.

The fourth factor was identified as Number on the grounds of very high coefficients on Number (.820) and Conservation of Plasticene (.753). This factor appears to represent an ability to perceive numerical relationships and transform them without loss of identity. As such it would be expected to correlate with Factor II. This is in fact the case although the coefficient is small (.210). No method yet exists to determine whether this correlation is significantly different

from one occurring by chance. The Varimax rotation shows Factor IV accounting for 16% of the common variance.

The fifth factor shows high coefficients on Counters (.937) and Shadow (.533) and was considered to be a Decentration factor. Shadow appears to require a form of decentration described by Inhelder and Piaget when they write:

> "In order to imagine perspectives the child must distinguish his own viewpoint from those of others and coordinate it with theirs [decentration]. In the case of shadows the light corresponds to the observer's viewpoint while the shadow is, in a sense, the negative of this. That is, the shadow is what cannot be seen from the place where the light is...." (1963, p. 207)

Counters require the envisioning of an infinite number of points in lineal relationship which Inhelder and Piaget claim is "essential to the completion of a qualitative concept of topological space" (1963). Such a completion requires Decentration.

Notwithstanding the above, it is felt that the identification of Factor V must be regarded as very tentative.

Only two tasks showed high coefficients on Factor VI, Time (.313) and Logical Inclusion (1.014). The latter was so substantial that an attempt to identify the factor was made.

The task appears to require the subject to separate parts from whole. Vernon (1965) linked Logical Inclusion with conservation tasks generally but in the present sample it failed to correlate above .18 on any other factor. The factor it represents shows negative correlations with Numerical Conservation (-.26), Visualization

(-.32), and Reversibility type B (-.25). Only a very small positive correlation was found with the Conservation factor (.19). As a result of its extremely high coefficient, and low coefficients among other tests, the factor has been named Logical Inclusion. However it is regarded as such with considerable reservation, since the lack of supporting evidence is obvious.

In view of the results obtained from the factor analyses the Piagetian tasks were recombined into 6 measures. Each was named for the factor from which it was drawn. Table VII shows the composition of the new measures which represent the summed normalized scores of the included variables.

Scores obtained on each of the Torrance tests of creativity were factor analyzed in the same manner as were the Piagetian scores.

Tables VIII, IX and X present the results of the analyses. In two cases only those loadings or coefficients with an absolute value greater than .30 are shown.

The correlation between the primaries exceeded .2 in but two cases. The correlation matrix is presented in Table XI.

An attempt was made to identify the factors on the basis of Promax oblique rotation coefficients. Additional evidence was provided by the other forms of factor analysis reported.

Tests which had high coefficients on the first factor were those under the general heading of Unusual Uses. They require verbal

TABLE VII

MEASURES DERIVED FROM FACTOR ANALYSIS
OF PIAGETIAN TASKS

NO.	NAME OF MEASURE	INCLUDED TASKS	COEFFICIENTS
1.	Reversibility A (RA)	Flexibility of H/s (b)	.854
		Flexibility of Foresight	.770
		Flexibility of H/s (a)	.658
2.	Reversibility B (RB)	Tilted Bottle	.835
		Towler Piaget Tasks	.670
		Insect	.653
3.	Conservation of Liquid and Area (CLA)	Conservation of Liquid	.845
		Conservation of Area	.672
		Time	.481
4.	Number (N)	Number	.820
		Conservation of Plasticene	.753
5.	Decentration (DEC)	Counters	.937
		Shadow	.533
6.	Logical Inclusion (LI)	Logical Inclusion	1.014

TABLE VIII

TORRANCE TESTS UNROTATED PRINCIPAL AXES FACTOR LOADINGS

VARIABLES	FACTOR LOADINGS I	II	III	IV	V	COMMUNALITY
Unusual Uses						
1. Fluency	.793	-.512	-.233	-.016	-.050	.947
2. Flexibility	.625	-.457	.176	-.208	-.072	.679
3. Originality	.776	-.510	-.165	-.087	-.069	.959
4. Elaboration	.800	-.510	-.172	.014	-.019	.930
Picture Construction						
5. Originality	.187	.177	-.731	-.231	.058	.658
6. Elaboration	.193	.067	.705	-.058	-.380	.686
Circles						
7. Fluency	.653	.623	-.072	-.080	.066	.830
8. Flexibility	.625	.452	.070	-.031	-.098	.610
9. Originality	.701	.640	-.036	.000	.064	.906
10. Elaboration	.641	.695	.005	-.085	.009	.901
Picture Completion						
11. Fluency	.318	-.161	.375	.512	.341	.646
12. Flexibility	.206	-.028	.162	-.137	.801	.729
13. Originality	.088	.035	-.232	.741	.177	.644
14. Elaboration	.188	.147	-.212	.505	-.443	.553
Percentage of Total Variance	30.3	18.7	10.4	8.6	8.3	76.3

TABLE IX

TORRANCE TESTS ROTATED FACTOR LOADINGS
(VARIMAX)

VARIABLE	FACTOR LOADINGS I	II	III	IV	V	COMMUN-ALITY
Unusual Uses						
1. Fluency	.957					.947
2. Flexibility	.748					.679
3. Originality	.975					.959
4. Elaboration	.944					.930
Picture Construction						
5. Originality			-.784			.658
6. Elaboration			.786			.686
Circles						
7. Fluency		.904				.830
8. Flexibility		.746				.610
9. Originality		.940				.906
10. Elaboration		.948				.901
Picture Completion						
11. Fluency			.418	.600		.646
12. Flexibility					.824	.729
13. Originality				.779		.644
14. Elaboration				.360	-.620	.533
Percentage of Total Variance	24.5	23.5	10.8	9.0	8.6	76.3

TABLE X

TORRANCE TESTS PROMAX PATTERNS ON THE PRIMARIES

VARIABLES	FACTOR LOADINGS I	II	III	IV	V
Unusual Uses					
1. Fluency	.991				
2. Flexibility	.721				
3. Originality	1.006				
4. Elaboration	.962				
Picture Construction					
5. Originality			-.802		
6. Elaboration			.819		
Circles					
7. Fluency		.919			
8. Flexibility		.729			
9. Originality		.947			
10. Elaboration		.967			
Picture Completion					
11. Fluency			.384	.578	
12. Flexibility					.853
13. Originality				.793	
14. Elaboration				.385	-.612

TABLE XI

CORRELATIONS BETWEEN PROMAX PRIMARIES
FOR TORRANCE TESTS

FACTOR	I	II	III	IV	V
I	1.000				
II	.228	1.000			
III	.261	.127	1.000		
IV	.134	.112	.056	1.000	
V	.138	-.054	.185	.020	1.000

expression of ideas for the use of a toy dog. Here Originality (1.006), Fluency (.991), Elaboration (.962) and Flexibility (.721) are the only variables with a coefficient greater than .10. The instrument as a whole is referred to as a test of verbal creativity by Yamamoto (1964) but the factor is here defined as Creativity-Unusual Uses.

Factor II was named Creativity - Circles since all the subtests of Torrance's "Circles" showed substantial coefficients. Once again the variables which appear to "hang together" are Elaboration (.967), Originality (.947), Fluency (.919) and Flexibility (.729). No other coefficient reached 0.2. Each of the variables named above is said to be associated with the production of non-verbal responses to non-verbal

stimuli (Yamamoto, 1964). Quite low but positive correlation (.228) between this factor and Factor I indicates a small relationship of a general ability kind, but the factor is not regarded as representing a non-verbal dimension of creativity, since it does not show correlation with the other supposed tests of non-verbal creativity.

Factor III is defined by the coefficients on the variables Originality (-.802) and Elaboration (.819), from the Picture Construction test. Again the subtests of the particular Torrance measure are the only ones appearing heavily on the factor, consequently it is difficult to achieve an interpretation beyond the test author's claim that the instrument is a measure of non-verbal creativity. Further, since there is no evidence of the presence of a peculiarly non-verbal factor, it is felt that the least bad labelling might be Creativity - Picture Construction.

The fourth factor is defined as Creativity - Picture Completion. The variables which display the higher coefficients are once again subtests of a particular Torrance test, Picture Completion. The coefficients, however, are neither as high nor as consistent as those appearing in Factors I and II. Furthermore, Flexibility is noticeably absent from the group. Originality (.79) and Fluency (.58) define the factor. Elaboration (.38) has the only other coefficient exceeding .25.

Factor V has only two variables with coefficients of absolute value greater than .3. It appears to be something of a flexibility factor, defined by a coefficient of .83 on Picture Completion

Flexibility, but the lack of supporting evidence, none of the other flexibility variables shows correlation on the factor, causes this interpretation to be very tentative. Consequently the factor is regarded as too doubtful to be included in the final analysis. As in the case of the Piagetian variables there is a striking lack of correlation between the Promax primaries. This may be a reflection of the differential development of abilities at this age level. Indeed the homogeneity of age may be tending to cloud relationships which could possibly be discerned were the age range greater.

As a result of the factor analysis, the Torrance Tests were combined into a series of measures of creativity as shown in Table XII. To obtain the measures, the normalized scores were summed for each variable included.

B. Results of Statistical and Factor Analysis of the Derived Measures.

Sixteen variables were available for analyses to test the hypotheses. Statistical methods were used for determining correlation coefficients and their significance or otherwise. Factor analysis was used to test hypothesis 2(c).

The variables and their identifying numbers are presented in Table XIII.

TABLE XII

MEASURES DERIVED FROM FACTOR ANALYSIS
OF TORRANCE TESTS

NO.	NAME OF MEASURE	INCLUDED TASKS	COEFF.
1.	Creativity - Unusual Uses (CUU)	Unusual Uses	
		Originality	1.006
		Elaboration	.991
		Fluency	.962
		Flexibility	.721
2.	Creativity - Picture Construction (CPCN)	Picture Construction	
		Elaboration	.819
		Originality*	-.802
3.	Creativity - Circles (CC)	Circles	
		Elaboration	.967
		Originality	.947
		Fluency	.919
		Flexibility	.729
4.	Creativity - Picture Completion (CPCL)	Picture Completion	
		Originality	.79
		Fluency	.58
		Elaboration	.38

*Scores were reflected on Originality in Picture Construction

TABLE XIII

VARIABLES USED FOR TESTING HYPOTHESES

NO.	VARIABLE	TYPE
1.	Age	Descriptive
2.	Occupation	Descriptive
3.	Raven's Coloured Progressive Matrices	Intelligence
4.	Hidden Figures	Intelligence
5.	Otis Verbal	Intelligence
6.	Otis Non-verbal	Intelligence
7.	Creativity - Unusual Uses	Creativity
8.	Creativity - Picture Construction	Creativity
9.	Creativity - Circles	Creativity
10.	Creativity - Picture Completion	Creativity
11.	Reversibility A	Piagetian
12.	Reversibility B	Piagetian
13.	Conservation of Liquid and Area	Piagetian
14.	Number	Piagetian
15.	Decentration	Piagetian
16.	Logical Inclusion	Piagetian

Hypothesis 1. Creativity and Intelligence.

(a) The scores obtained on separate measures of creativity will correlate positively and significantly with those obtained on separate measures of intelligence.

Table XIV shows the intercorrelations between creativity and intelligence measures.

TABLE XIV

INTERCORRELATIONS BETWEEN CREATIVITY AND INTELLIGENCE MEASURES

VARIABLE	RCPM	HF	OV	ONV	CUU	CPCN	CC	CPCL
RCPM	1.000							
HF	.385**	1.000						
OV	.483**	.305**	1.000					
ONV	.324**	.388**	.390**	1.000				
CUU	.126	.209*	.348**	.319**	1.000			
CPCN	.178	.110	.050	.092	-.059	1.000		
CC	.148	.143	.121	.162	.218*	.220*	1.000	
CPCL	.117	.045	.304**	.096	.097	.147	.214*	1.000

Note:
*Significant at .05 level (one-tailed)
**Significant at .01 level (one-tailed)

Of the 16 Creativity - Intelligence correlation coefficients 4 reached significance at the .05 level. Creativity - Unusual Uses correlated with Otis Verbal (.35), Otis Non-verbal (.32) and Hidden Figures (.21). Creativity - Picture Completion and Otis Verbal correlated .30.

(b) There will be a positive and significant correlation of total creativity and total intelligence scores.

Correlation between the summed normalized scores indicated a significant and positive relationship. The correlation coefficient was 0.363. ($p < .005$), as indicated in Table XVI.

Hypothesis 2. Creativity, Intelligence and Reversibility.

(a) Scores obtained on measures of reversibility derived from factor analysis of the batteries of Piagetian tasks will correlate positively and significantly with those obtained on separate measures of both the creativity and intelligence tests.

Table XV presents the correlation matrix of Creativity, Intelligence and Reversibility measures. Those Piagetian measures not labelled reversibility are not included in the table.

Of 8 correlations between the Reversibility measures and Intelligence, 6 are significant at the .05 level. Reversibility and Creativity variables correlated significantly at the .05 level on 3 of 8 possible correlations.

Reversibility A is correlated significantly with Creativity -

TABLE XV

INTERCORRELATIONS BETWEEN CREATIVITY, INTELLIGENCE AND REVERSIBILITY

VARIABLE	RCPM	HF	OV	ONV	CUU	CPCN	CC	CPCL	R A	R B
RCPM	1.000									
HF	.385**	1.000								
OV	.483**	.305**	1.000							
ONV	.324**	.388**	.390**	1.000						
CUU	.126	.209*	.348**	.319**	1.000					
CPCN	.178	.110	.050	.092	-.059	1.000				
CC	.148	.143	.121	.162	.218*	.220*	1.000			
CPCL	.117	.045	.304**	.096	.097	.147	.214*	1.000		
R A	.097	.102	.274**	.292**	.495**	.037	.420**	.128	1.000	
R B	.415**	.789**	.335**	.435**	.186*	.083	.129	.123	.164	1.000

Note:
*Significant at .05 level (one-tailed)
**Significant at .01 level (one-tailed)

Unusual Uses and Creativity - Cirles, and also with Otis Verbal and Otis Non-verbal. In each case $p < .01$.

Reversibility B is positively correlated ($p < .005$) with every intelligence measure and in addition is correlated ($.01 < p < .05$) with Creativity - Unusual Uses.

(b) Total scores obtained on the reversibility measures will correlate positively and significantly with total scores on creativity and intelligence.

Table XVI shows the matrix of correlations for the four variables: Total Creativity, Total Intelligence, Reversibility A and Reversibility B.

TABLE XVI

INTERCORRELATIONS BETWEEN TOTAL SCORES FOR CREATIVITY, INTELLIGENCE, REVERSIBILITY A AND REVERSIBILITY B

VARIABLE	TOTAL C	TOTAL I	R A	R B
TOTAL C	1.000			
TOTAL I	.363**	1.000		
R A	.518**	.282**	1.000	
R B	.217*	.676**	.164	1.000

Note:
*Significant at .05 level (one-tailed)
**Significant at .01 level (one-tailed)

Both Reversibility A and Reversibility B are significantly and positively correlated with total intelligence and total creativity. Reversibility A being more highly correlated with total creativity, and Reversibility B being more highly correlated with total intelligence.

(c) Factor analysis of the derived measures will produce a factor defined by reversibility which will also load positively on creativity and intelligence.

All 16 variables were used to test hypothesis 2 (c).

Tables XVII, XVIII, and XIX present the results of the analyses. Table XX shows correlations between Promax primaries for the final battery.

High loadings of several tests on the first unrotated factor suggest it to be a general ability factor. This gives some support to the hypothesis, since both measures of reversibility are seen to load on it as do all the intelligence measures and all but one of the creativity measures.

The Promax oblique solution also moderately indicates a general factor. Factor I has been defined as Reversibility B on the basis of high coefficients on Hidden Figures (.880), Raven's Coloured Progressive Matrices (.670), Otis Non Verbal (.624) and Reversibility B (.896).

It appears to be closely connected to the general factor traditionally found to be present in tests such as Raven's Coloured Progressive Matrices and the Otis.

Factor II is identified by high coefficients on Reversibility A (.845), Creativity - Unusual Uses (.723), Decentration (.716), and Creativity - Circles (.564). It appears closely related to flexibility and fluency of hindsight and foresight since it has correlations associated with creativity measures, however it has been named

TABLE XVII

FINAL BATTERY UNROTATED PRINCIPAL AXES FACTOR LOADINGS

NO. VARIABLES	FACTOR LOADINGS I	II	III	IV	V	VI	COMMUNALITY
1. AGE	.266	-.183	-.510	.453	-.114	-.151	.605
2. OCC	.230	-.047	.412	-.361	-.307	-.459	.660
3. RCPM	.635	-.381	-.138	.026	-.128	.035	.586
4. HF	.675	-.473	.006	.031	.088	.161	.714
5. OV	.634	-.052	.090	-.257	-.104	.059	.493
6. ONV	.594	.151	.337	.106	.269	.025	.574
7. CUU	.569	.327	-.042	-.288	.375	.108	.668
8. CPCN	.164	.093	.182	.512	-.477	.175	.588
9. CC	.452	.421	-.029	.477	.022	.029	.611
10. CPCL	.308	-.451	.279	-.084	-.619	.157	.629
11. RA	.592	.556	-.075	-.019	.201	-.082	.713
12. RB	.706	-.451	.111	.081	.095	.131	.748
13. CLA	.207	.096	-.501	-.430	-.247	.422	.727
14. N	.260	.446	.124	-.118	-.138	.632	.714
15. DEC	.377	.420	-.236	.132	.085	-.340	.514
16. LI	.142	.114	.596	.194	.272	.255	.564
Percentage of Total Variance	21.9	10.5	8.6	7.8	7.4	7.0	63.2

TABLE XVIII

FINAL BATTERY ROTATED FACTOR LOADINGS* (VARIMAX)

NO. VARIABLES	I	II	III	IV	V	VI	COMMUN-ALITY
1. AGE			-.580			.314	.605
2. OCC				.781			.660
3. RCPM	.682		-.301				.586
4. HF	.838						.714
5. OV	.495			.381			.493
6. ONV	.633						.574
7. CUU		.670					.668
8. CPCN						.756	.588
9. CC		.589				.498	.611
10. CPCL				.676		.372	.629
11. RA		.807					.713
12. RB	.860						.748
13. CLA			-.365		.756		.727
14. N			.337		.709		.714
15. DEC		.668					.514
16. LI			.723				.564
Percentage of Total Variance	17.1	13.2	8.5	8.4	8.0	8.0	63.2

*Factor loadings between -.3 and .3 omitted

TABLE XIX

FINAL BATTERY PROMAX PATTERN ON PRIMARIES*

NO.	VARIABLE	FACTOR COEFFICIENTS I	II	III	IV	V	VI
1.	AGE			-.566			
2.	OCC				.828		
3.	RCPM	.670					
4.	HF	.880					
5.	OV	.394			.333		
6.	ONV	.624		.312			
7.	CUU		.723				-.375
8.	CPCN						.784
9.	CC		.564				.455
10.	CPCL				.707		.430
11.	RA		.845				
12.	RB	.896					
13.	CLA			-.366		.785	
14.	N			.337		.710	
15.	DEC		.716				
16.	LI			.736			

*Factor coefficients between -.3 and .3 omitted

TABLE XX

CORRELATIONS BETWEEN PROMAX PRIMARIES FOR FINAL BATTERY

FACTOR	I	II	III	IV	V	VI
I	1.000					
II	.365	1.000				
III	-.101	-.003	1.000			
IV	.237	.174	.064	1.000		
V	.100	.140	.036	.233	1.000	
VI	.058	.183	-.038	-.104	-.066	1.000

Reversibility A and it is felt that the factor represents a facility in handling classifications through the use of the inverse operator.

The correlation existing between the factors (.365) would likely be significant at the .05 level at least, and it suggests that an overlap, possibly in the nature of a small "g," may be present.

Factor III has been named Eduction of Numerical Combinations. However, considerable reservation is placed upon this identification. Logical Inclusion (.736), Number (.337), and Otis Non-verbal displayed positive correlations. Logical Inclusion requires the subject to separate parts from wholes on the basis of changing combinations among the parts. Number also requires the formation of combinations.

Piaget (1950) suggests that these operations are similar to the process Spearman calls "eduction of correlates." He refers to the arrangement of combinations in seriations and simple correspondences (Ibid, p. 46). He does not, however, directly refer to the tests included in Logical Inclusion and Number.

Factor IV appears to be connected with socio-economic status in view of the high coefficient of Occupation (.828), Creativity - Picture Completion (.707), and Otis Verbal (.333) correlated positively on the factor. Since evidence exists for the assumption of a socio-economic factor in verbal intelligence, the Otis Verbal coefficient adds some support to the labelling of Factor IV as Socio-economic Status. It should be pointed out here that the factor is defined in terms of the descriptive data described in Chapter IV and is not intended to be interpreted as Socio-economic Status in a broad sense.

The fifth factor seems likely to be a conservation factor, since both Conservation of Liquid and Area (.785) and Number (.710) correlate positively. Number includes Conservation of Plasticene, hence the factor contains all the supposed conservation tasks used in the derived measures.

Creativity - Picture Construction (.784), Creativity - Circles (.455) and Creativity Picture Completion appear on Factor VI with positive coefficients. In the opposite direction is Creativity-Unusual Uses (-.375). Creativity - Unusual Uses requires verbal

responses while the other three creativities are primarily non-verbal. As a result it seems likely that Yamamoto's (1964) classification of the latter as non-verbal creativity may be defensible. Consequently the factor has been labelled Non-verbal Creativity.

CHAPTER VI

DISCUSSION

A. Factor Analysis of Piaget and Torrance Batteries

The intercorrelation matrices of the Piaget and Torrance variables reflected the need for factor analyses to achieve parsimony of interpretation. Correlation between the subtests of the Torrance tests ranged from -.303 to .975 while the range in the Piaget battery was -.208 to .570. This was not altogether surprising in either case, since the diversity of abilities required for success across the variables was considered likely to be wide.

The factors which arose in the analysis of the Piaget batteries did not entirely fit the expected pattern, however they are in line with many of Piaget's postulates. There is evidence of a general ability in loadings on the first unrotated factor, which had its strongest weightings on the Piaget/Inhelder flexibility of hindsight and foresight tasks. This lent support to their position (1964) which suggested that such flexibility was essential for the development of operational schemata, and would consequently appear as a mechanism in most tasks requiring concrete and formal operations.

Of more interest at this point however, are the results of the oblique rotations. Higher correlations were expected between the factors than were actually obtained.

Little relationship was found between Reversibility as Inversion

in classes and Reversibility as Reciprocity in relations. This seems very likely to be a result of the age of the children in the study. Flavell (1963, p. 204) writes:

> "The 7-11 year old, while possessing the two kinds of reversible operations to be found in the concrete-operational groupings - negation or inversion, indigenous to the class groupings, and reciprocity, found in the relation groupings--does not possess a total system which permits him to coordinate the two and thereby solve multivariable problems which require this kind of coordination. Just as the various content areas resist a single, once-for-all structuring by the concrete-operational child, so his various cognitive structures--adequate though they may be in their own separate dominions--fail to combine into the unified whole necessary to manage certain complex tasks."

The size of the coefficients between the tasks on the first factor indicated that they might be combined as a measure. Labelling of the factor as Reversibility A was in accord with Inhelder and Piaget's (1964) view of the nature of the structures underlying the development of reversible operations, but it was felt that the tasks were requiring abilities very similar to those suggested by Torrance (1963) and Guilford (1959) as basic to the production of creative solutions to problems.

The second factor obtained from the Piaget battery was named Reversibility B because it seemed to represent the operation of reversibility in spatial relationships. Inhelder and Piaget (1963, p. 126) in writing of the development of points and continuity in topological space state that:

> "the process of reducing what is regarded as continuous to a series of adjoining points and recreating an operational continuity on the basis of these points, a process thereby identified as one of reversible combination, is the most advanced type of the operations involved in separating enclosed parts."

When a problem involving the visualization of an object or design in a different position or from a different perspective occurs, Inhelder and Piaget propose that its solution arises out of the child's transition from ego-ecentric realism to relational co-ordination. The latter involves the operational co-ordination of view points, and it is characterized by reversibility. (Inhelder and Piaget (1963), Piaget, 1961).

Flavell (1963) points out that Piaget is really concerned with representation of space rather than perception, and the tasks which show high coefficients on Factor II require the representation of changed spatial relationships. Piaget, according to Flavell (Ibid, p. 328) is "almost obsessional" in his insistence that spatial representations are built up through the organization of actions into operational systems rather than direct perception of "obvious" relations. Piaget (1961, p. 274) states that:

> "concerning space, in particular, it is obvious that every motor totality tends to form a "group" whose elements are defined precisely by reciprocity."

Earlier (1928, p. 134) he had suggested that:

> "It is precisely because he fails to grasp the reciprocity existing between different points of view that the child is unable to handle relations properly."

The results of the present study are consistent with Piaget's position on the dual nature of reversibility in concrete operations.

Those tasks requiring the organization of relationships (the spatial visualization tasks) have tended to correlate on Factor II while those tasks having to do with inclusion of classes (the flexibility tasks) have correlated on Factor I.

This is consistent with the effect of the ages of the sample and it is possible that the two factors would correlate were the age range widened to include boys from the early concrete operational stage to the early propositional stage.

It appears that flexibility of hindsight and foresight as measured by the author's interpretation of Inhelder and Piaget's clinical method, and the space relationship-orientation tasks of Vernon's and Towler's interpretation, are related to the two types of reversibility but not to each other within the sample under study.

The low coefficients of the conservation tasks on the first two factors may also be attributable to the narrow age range. It had been expected that they would appear on both types of reversibility but it is pointed out that each subtest of conservation in Vernon's battery is at some different point in Piaget's continuum of development. Hence the effect of reversibility in specific conservation tasks may have been clouded. Two of the four conservation tasks did show coefficients above .3 and another (Conservation of Area) reached .18 on

Reversibility A. Again, it is suggested that a sample from grades I through X might produce a different factoral structure so that conservation and both forms of reversibility were more closely linked. In this study however it seems clear that there is a conservation factor not closely associated with either type of reversibility.

The factor analysis of the Torrance variables did not produce a general creativity factor, nor did a clear division of verbal and non-verbal types of creative ability appear.

The inability of the subtests to produce factors definable by the supposed contents of the subtests made it impossible to derive measures representing fluency, flexibility, originality and elaboration. Instead, it was noted that each of the tests appeared to be tapping a different set of abilities supposed to be creativity. Therefore they were regarded as separate measures of different types of creativity. Nevertheless, it is felt that the analysis points out the difficulty in claiming tests of creativity to be so. If creativity <u>is</u> a unified dimension, it was not exposed as such by the tests included from Yamamoto's list.

It is possible that a great generality between the subtests and total scores might exist among an older sample. Indeed, in the limited age range used in this thesis it is at least a possibility that the variables may have been measuring a collection of abilities only minimally related to the supposed domain.

Despite the hanging together of the parts of each separate Torrance Test, it was considered necessary to recombine them as reported in Chapter V. In view of the results obtained it appears unwise to sum the scores on subtests of proposed creativity measures and consider the total representative of ideational fluency, flexibility, originality or elaboration on the basis of their being so named by the test author.

B. The Hypotheses

1. Creativity and Intelligence

Since only 4 of the 16 possible creativity - intelligence correlations reached significance at the .05 level, some support is given to those theorists who suggest that creative behaviour and intelligence are not strongly related. The range of the correlations (.05 and .35) indicates that the most substantial overlap between a creativity and an intelligence measure did not exceed 12.25% of common variance.

The results do not, however, confirm the existence of a <u>unified</u> dimension of creativity. The correlations between the measures do not reach the size of the correlations between the intelligence tests nor do they exhibit the same consistency. None of the intercorrelations between the creativities reaches significance at the .01 level, while all the intelligences are significant beyond the .01 level.

The findings are consistent with those reported by Cropley (1965), Pribram (1964), and Cline, Richards and Needham (1963). In

all of these studies, it was found that creativity and intelligence were not closely correlated, however none showed a distinctly unified dimension of abilities that could be defensibly regarded as creativity. The claim of Getzels and Jackson (1962) to have measured such a dimension can not be repeated in the present study. It is possible that the composition of the sample used in this thesis may have concealed the presence of a strongly unified domain. The range of IQ (73-141) is substantially different from that reported by Getzels and Jackson, most of whose subjects had IQs exceeding 130.

Vernon (1964) has proposed that intelligence and creativity may become separate and unified dimensions above a minimum IQ which he supposes may be in the neighbourhood of 120. The heterogeneity of IQ in the sample would thus tend to obscure the possible differentiation of creativity and intelligence in children with high IQs, should Vernon's hypothesis be accepted.

When the separate creativity measures were summed to provide a composite "Creativity" score, Ohnmacht's (1966) warning was noted. Consequently results obtained should be interpreted with the low intercorrelations of the creativities in mind.

A coefficient (.363) representing a common variance equal to 13.2% of the total variance was obtained between Total Creativity and Total Intelligence.

Although this relationship is highly significant ($p < .005$) it should not be regarded as strong evidence that a fundamentally

separate dimensionality of creativity from Intelligence does not exist.

In view of the nature of the sample, the method of deriving the separate measures and the subsequent combination of them it is perhaps better to consider the results indicative of a possible, small relationship which may vary substantially under different experimental conditions.

2. Creativity, Intelligence and Reversibility

An examination of the correlation matrix for Creativity, Intelligence and Reversibility A and B reveals 6 significant correlations between the Reversibilities and Intelligence and 3 between the former and Creativity. The reversibility measures did not reach significance at the .05 level between each other ($.10 > p > .05$) and consequently can not be regarded as substantially related. This is consistent with Piaget's view of the nature of reversibility in the child at the concrete operations level. There is some evidence in the obtained results that inversion and reciprocity have not been combined into a single reversibility of the type occurring in formal (propositional) operations. The highly significant correlation of Reversibility B with the 4 measures of intelligence ($p < .005$ in all cases) indicates a relationship of a general type since the measures are traditionally believed to possess a "g" factor.

It is possible that the creativity measures which correlate with Reversibility A may be doing so because of the flexibility of

hindsight and foresight believed to be present in Reversibility A.

The question asked in this thesis centered around the relationship of Reversibility to Intelligence and Creativity. The correlation matrix presented in Table XVI (p. 59) may supply a partial answer.

Piaget defines intelligence in children as:

> "...the state of equilibrium towards which tend all the successive adaptations of a sensor-motor and cognitive nature, as well as all assimilatory and accommodatory interactions between the organism and the environment," (1950, p. 11)

Flavell (1963) states that Piaget, throughout his writings, uses the terms "reversibility" and "equilibrium" almost interchangeably. He quotes Piaget as claiming that:

> "An operation is a regulation which has become completely reversible in a system completely equilibrated, and become completely reversible because completely equilibrated." (Ibid, p. 243)

The results obtained in this thesis are generally in support of Piaget's position. The appearance of Reversibility A and B as separate factors with the highest proportion of total variance among all the Piagetian variables is probably the most significant finding of the first factor analyses. That one should correlate strongly with Intelligence and the other with Creativity was not anticipated, but it is felt that the finding may provide a clue to the separate natures of intelligence and creativity.

Reversibility A's relationship to the two creativity measures as reported in Chapter V, may be in the nature of flexibility of

hindsight and foresight in handling classes of ideas. Inversion in groupements of classes may be the intellectual correlate of creativity in the sample studied. It is possible that at this age level the strategies associated with the creative process are combinatorial in a classificatory rather than a relational sense. This suggests that children succeeding on the creativity measures are able to produce appropriate responses within the framework of simple classifications. They do not seem to be employing reciprocity, as an adjunct to inversion, to a large extent, although Reversibility B does appear to bear some relationship to creativity. Such a finding again tends to support Piaget's contention that inversion and reciprocity are not combined into one operation at the concrete level.

It is tempting to suggest that inversion is the type of reversibility more closely connected to the creative process and reciprocity is the type of reversibility more closely related to intelligence. The results of this thesis would support such a proposition. There is strong evidence in the data that Reversibility B is clearly connected with general intelligence. Flexibility of hindsight and foresight in the handling of relationships would thus be recognized as a key factor in the general intelligence domain. But it must be remembered that the age of the sample approaches homogeneity and that the boys are within the early to middle period of concrete operations.

Clearly the reversibilities are only slightly related to each other, and just as clearly they are strongly represented in either

Intelligence or Creativity. The question of their continued separation in older children has not been investigated, consequently no statement of an increased relationship of Reversibility A to Intelligence or Reversibility B to Creativity can be made.

Factor analysis of the final battery produced further evidence of the association of Reversibility A with Creativity and Reversibility B with Intelligence. In each case the reversibility measure displayed the highest coefficient.

Of some interest is the tendency of the 3 non-verbal types of creativity to cluster on Factor VI. This factor contributed 8% of the total variance (Varimax) but it does indicate the existence of a possible dimension of non-verbal creativity. Cropley (1965) also found a tendency for originality (sic) to cluster on a factor possessing a relatively low percentage of the total variance.

The failure of the conservation measures to be strongly represented on factors defined by either of the reversibilities may have been the result of the homogeneous ages of the sample. It is considered likely that reversibility is actually a factor in conservation. Consequently further studies in which a greater number of tasks requiring a wide range of conservation structures are combined with both types of reversibility are probably warranted. Such a battery applied to children at various levels of operations might be expected to produce more revealing evidence regarding the relationship of reversibility with conservation than has this thesis.

CHAPTER VII

SUMMARY, CONCLUSIONS, IMPLICATIONS

Summary

The role of Piaget's concept of reversibility in intelligence and creativity was investigated through the testing of 5 hypotheses concerning the nature of possible relationships between creativity and intelligence, and between creativity, intelligence and reversibility.

Three batteries of Piagetian tasks, 4 Torrance tests of Creativity, Raven's Coloured Progressive Matrices, Hidden Figures, Otis Verbal and Otis Non-Verbal were administered to 85 Edmonton Public School boys aged between 8 years and 9 years 6 months. Testing was conducted by the investigator in all Grade III classes at Laurier Heights, Garneau and Queen Alexandra Elementary Schools during November and December 1966.

The Canadian Occupational Scale was used to provide an indication of socio-economic status, and age in months was calculated for each subject.

A total of 35 variables were available for initial analysis. The Torrance tests and Piagetian tasks were combined on the basis of orthogonal and oblique factor analyses into 4 measures of creativity, 2 measures of reversibility (inversion, and reciprocity) and 4 additional Piagetian variables. Intelligence tests, age, and occupation

were included with the derived measures to provide a battery of 16 variables on the basis of which the hypotheses were tested.

Pearson Product Moment correlation coefficients and Principal Axis, Varimax orthogonal rotation and Promax oblique solution factor analyses were used to test the hypotheses.

Conclusions

The conclusions with regard to each hypothesis are presented individually.

Hypothesis 1. Creativity and Intelligence

(a) The scores obtained on separate measures of creativity derived from factor analysis of Torrance tests of creativity will correlate positively and significantly with those obtained on separate measures of intelligence.

Sixteen creativity-intelligence correlations resulted in 4 significant coefficients at the .05 level (Creativity - Unusual Uses with Otis Verbal, Otis Non-verbal, and Hidden Figures; Creativity - Picture Completion with Otis Verbal). No correlation accounted for more than 12.25% of the total variance, hence it was concluded that some evidence of relationship between creativity and intelligence as measured by the separate variables exists, but that this relationship is small, not general, and, in view of the narrow age-range, inconclusive.

(b) There will be a positive and significant correlation of

total creativity and total intelligence test scores.

Total creativity and total intelligence (derived by summing the normalized scores of the variables included in each category) correlated significantly at the .05 level. However, only 13.2% of the total variance was accounted for. As a result it was concluded that a small relationship exists between creativity and intelligence within the sample studied. However, the nature of the derivation of total creativity and total intelligence, the narrow age range and heterogeneity of IQ in the sample, and the size of the coefficient, prevented the assumption of unidimensionality of creativity and intelligence.

Hypothesis 2. Creativity, Reversibility and Intelligence

(a) Scores obtained on measures of reversibility derived from factor analysis of the batteries of Piagetian tasks will correlate positively and significantly with those obtained on the separate measures of both the creativity and intelligence tests.

Of 8 Reversibility - Intelligence possibilities, 6 correlations (Reversibility A with Otis Non-verbal and Otis Verbal: Reversibility B with every intelligence variable) were significant at the .05 level. Reversibility and creativity measures reached significance at the .05 level on 3 of 8 possible correlations. Reversibility A correlated with Creativity - Unusual Uses and Creativity - Circles. Reversibility B correlated with Creativity - Unusual Uses.

It was concluded that a general and highly significant relationship ($p < .005$) exists between Reversibility B (the reversibility of

relations) and Intelligence. The relationship between Reversibility A and creativity is seen to be less general, but it was concluded that, within the sample studied, Reversibility A tends to be more closely connected with creativity variables while Reversibility B is more closely related to intelligence. It was further concluded that no significant relationship exists between Reversibility A and Reversibility B in children at the concrete operational stage of intellectual development.

(b) Total scores obtained on the reversibility measures will correlate positively and significantly with total scores on creativity and intelligence.

Reversibility A and Reversibility B both correlated significantly and positively with total intelligence and total creativity, Reversibility A being more highly correlated with total creativity (.518), while Reversibility B is more highly correlated with total intelligence (.676).

It was concluded that a substantial and highly significant relationship ($p < .005$) exists between the reversibility of classes (inversion) and creativity on the one hand and between the reversibility of relations (reciprocity) and intelligence on the other.

(c) Factor analysis of the derived measures will produce a factor defined by reversibility which will also load positively on creativity and intelligence.

Analysis of the 16 variables produced 6 factors with

eigenvalues greater than 1.00. These were identified as Reversibility A, Reversibility B, Eduction of Numerical Combinations, Socio-economic Status, Conservation, and Non-verbal Creativity.

The high coefficients of intelligence variables on the factor defined by Reversibility B led to the conclusion that Reversibility B is closely connected to intelligence and that this connection appears to be of a nature traditionally referred to as "g."

The appearance of two creativity variables on the factor defined as Reversibility A was considered to indicate the relationship of the reversibility of classes to creativity and it was concluded that flexibility of hindsight and foresight in classifications is likely to be an important element in creativity.

Implications

The data obtained have provided a partial description of the role played by Reversibility in Creativity and Intelligence. It seems likely that reversibility of relations is a very important element in general intelligence. The role of reversibility in creativity is clouded because of the insecurity of interpretation of results obtained in the Torrance Tests. If these are accepted as valid measures in the sample studied, then it appears that reversibility of classes is of importance in creativity.

A number of implications which might form the basis of further research has arisen from the results.

The finding of differential reversibility in a sample at the concrete operational level raises the possibility that a study using a sample of considerably wider age range might be able to investigate Piaget's hypothesis that inversion and reciprocity combine to form one reversibility in propositional operations.

The appearance of reversibility of relations as a strong element in intelligence suggests the need for additional research to determine whether the relationship holds among older children, especially those who have reached the level of formal operations.

The nature of the connection of reversibility of classes with creativity appears likely to be a justifiable area of research.

In this study the possible relationship of flexibility of hindsight and foresight to ideational flexibility and fluency could not be assessed, since no clear factors of fluency and flexibility of ideas were established. Nevertheless the high Promax coefficients imply that the psychological abilities underlying creativity tests are similar to those required for success on the Inhelder/Piaget tasks. Reference to the correlation matrix for the Piaget and Torrance variables (Appendix III) indicates that substantial relationships exist between the flexibilities in each of the Torrance tests and the subtests of the Inhelder/Piaget battery. Once again, investigation of these relationships may be more effective if an older sample is used. This could result in the appearance of significant correlation between the flexibility scores on creativity measures and the presence of a

flexibility factor.

The implications of the study for educational practice appear to lie in the nature of the differential relationship of the two reversibilities with creativity and intelligence.

Since it seems that reciprocity is closely connected with the functioning of traditional intelligence, it may be that children regarded as "dull" could be helped by the provision of practice in the perception of relationships.

Should future research indicate that flexibility of hindsight and foresight in classes continues to have a highly significant association with creativity, the development of the creative process in children might be assisted by providing opportunities to handle classificatory tasks similar to those described by Inhelder and Piaget (1964).

In short, it seems that attention to the development of inversion and reciprocity in operations may assist the child to function more effectively in both creativity and intelligence.

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APPENDICES

APPENDIX I

References for unpublished Piagetian tasks.

Adaptation of Inhelder/Piaget tasks.

References for unpublished group tests.

REFERENCES FOR UNPUBLISHED PIAGETIAN TASKS

1. Vernon adaptation of Piagetian tasks.

   Materials, administration and scoring procedures are reported by Vernon, P.E., Environmental handicaps and intellectual development. Brit. J. Educ. Psychol., 1965, 35, (1) 9-20.

2. Towler/Piaget tasks.

   Materials (pages 132-4) and scoring procedures (page 140) are described by Towler, J.O., Children's spatial concepts. Unpublished master's thesis, University of Alberta, 1965.

3. Inhelder/Piaget tasks.

   The clinical procedures from which the Inhelder/Piaget battery was formulated by the investigator appears in Inhelder, B., and Piaget, J., The early growth of logic in the child. London: Routledge and Kegan Paul Ltd., 1964, pages 197-231.

ADAPTATION OF INHELDER/PIAGET TASKS IN FLEXIBILITY OF HINDSIGHT AND FORESIGHT

Description:

Three tasks are presented, each of which uses a different set of apparatus.

Task (a) requires reclassification of an existing arrangement of the stimulus material on the basis of the addition of a new element.

Apparatus (a): Two boxes approximately 6" long by 4" wide by 2" high.

1. Three flat green circles and 3 flat green crosses, 50mm in diameter and length respectively.

2. Three yellow stars of the same size and card.

3. Three mauve rhombi and 3 mauve semi-circles of 50mm side and diameter.

4. Three brown corrugated cardboard triangles and 3 ovals with side and long axis respectively 50mm.

Instructions and scoring:

Here are two boxes. I am going to give you a number of cut outs which I want you to put into the boxes so that all the things in the first box will be in some way like each other, and all the things in the second box will also be like each other in some way. *Each time that I give you some new things try to make another way of putting them into the boxes. You may tip all the cut-outs out of the box

if you wish and start over. If you can think of more than one way to put the cut-outs into the boxes so that they are alike, then go ahead and do those ways too.

Stimulus material is presented in the order suggested above. If the subject is unsure on the procedure the examiner repeats the instructions from * on. After each new presentation the examiner says "See if you can think of another way to put them in the boxes." After successful completion of each rearrangement the examiner says "Are there any other ways to do it?"

Each rearrangement judged a valid dichotomy scores one point.

Task (b) requires the production of as many reclassifications as the subject is able to make from the stimulus material, all of which is presented simultaneously.

Apparatus (b): Two 6" by 4" by 2" boxes.

1. Three red circles and 3 red squares of diameter and side respectively equal to 50mm.

2. Three red circles and 3 red squares of diameter and side respectively equal to 25mm.

3. Three blue circles and 3 blue squares of diameter and side respectively equal to 50mm.

4. Three blue circles and 3 blue squares of diameter and side respectively equal to 25mm.

Instructions and scoring:

Here are some more cut-outs. This time they are all here. Tell me what they are.

Now put them into the boxes so that all the objects in one box will be in some way alike and all the objects in the other box will be in some way alike.

(After each classification the contents of the boxes are scattered and the subject is asked to make a further dichotomy).

See if you can find another way to put them into the boxes so that all the objects in one box are alike in some way and all the objects in the other box are also alike in some way.

One point is scored for each valid dichotomy. No point is given for naming the objects.

Task (c) requires the provision of a verbal classification of the stimulus material followed by a carrying out of the stated classification.

Apparatus (c): Six 6" by 4" by 2" boxes.

1. Six circles, of which 3 are of 6cm diameter and 3 are of 3cm diameter.

2. Six squares, of which 3 are of 6cm side and 3 are of 3cm side.

3. Six right angled isosceles triangles of which 3 are 6cm on the equal sides and 3 are 3cm on the equal sides. Each set

of 3 consisted of one blue, one red and one yellow element.

Instructions and scoring:

Here is a number of boxes and here are some more objects. One again I want you to put the objects that are the same in some way into one box. Since we have quite a lot of objects this time, you may need to use more than two boxes.

Before you put the objects in the boxes, tell me how you are going to do it, and in what way the objects are alike. (Repeat if necessary. After the subject completes the first classification the objects are scattered on the table).

Now see if you can do it another way. Remember. Tell me how you are going to do it before you start then go and do it. (Repeat after each classification until responses are exhausted).

Score one point for stated valid classification and one point for a completed classification.

REFERENCES FOR UNPUBLISHED GROUP TESTS

1. Hidden Figures.

   A statement regarding the derivation of the Hidden Figures test is given by Vernon, P.E., Environmental handicaps and intellectual development. Brit. J. Educ. Psychol., 1965, 34, (2) page 119.

2. Torrance Tests of Creativity.

   A full description of each test including administration, and scoring procedures, appears in Yamamoto, K., Experimental scoring manuals for Minnesota tests of creative thinking and writing. Research Mono. Ser. 1, Ohio: Kent S.V., 1964.

INTRODUCTION TO TESTING

I would like you to help me in some work I am doing. I will give you lots of little tasks to do. Do the best you can.

APPENDIX II

Adaptation of Inhelder/Piaget tasks: Answer Sheet.

INHELDER-PIAGET BATTERY

TEST 1. Flexibility of hindsight. (A)

Response Score

TEST 2. Flexibility of Hindsight. (B)

Response Score

TEST 3. Flexibility of Anticipation. (Foresight)

Response Score

APPENDIX III

Torrance Tests: Piaget Tasks

Final Battery

Correlation Matrices

CORRELATION MATRIX: TORRANCE TESTS*

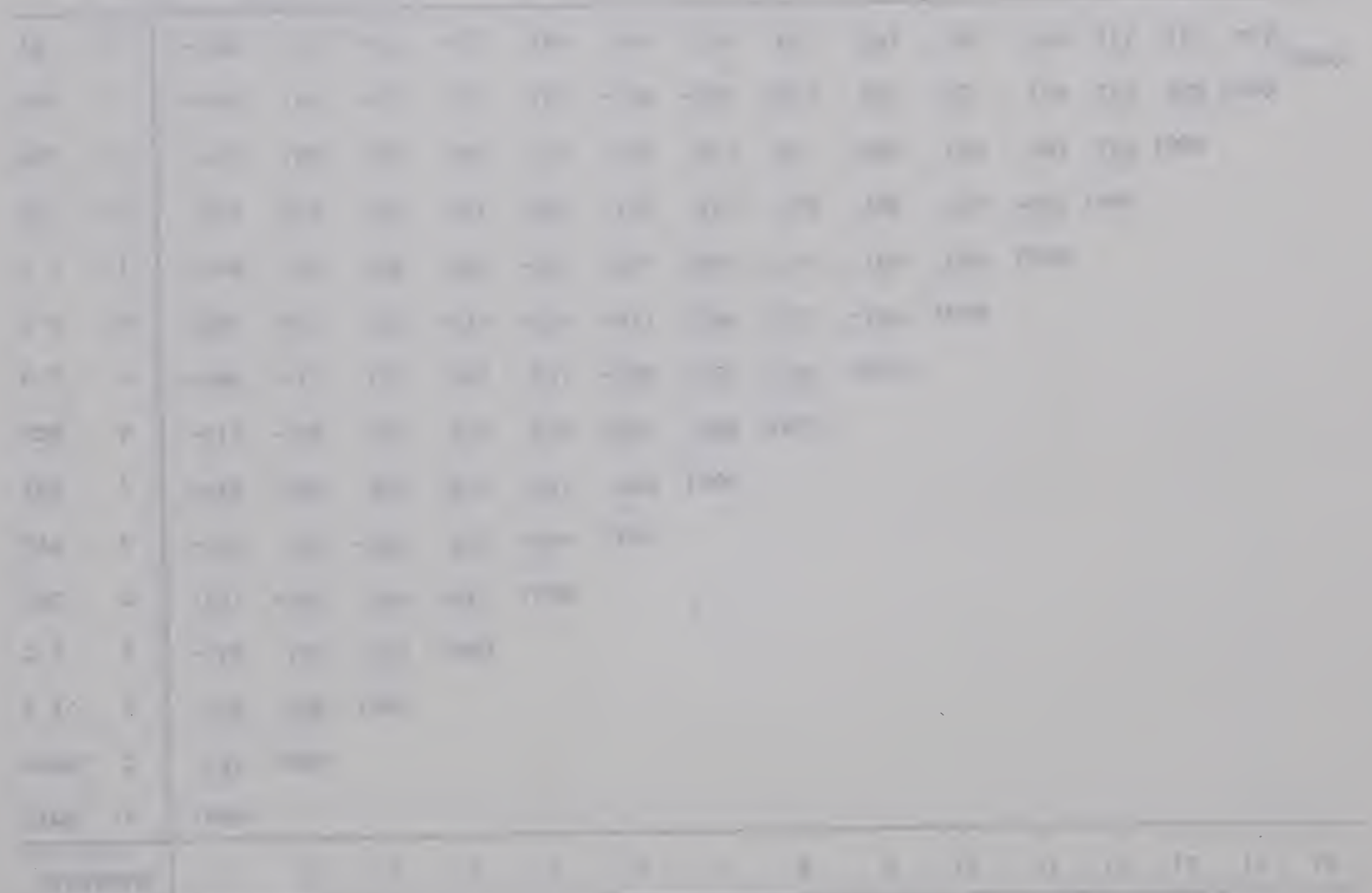
VARIABLE		1	2	3	4	5	6	7	8	9	10	11	12	13	14
U U FLU	1	1000													
U U FLE	2	601	1000												
U U O	3	945	695	1000											
U U E	4	960	601	929	1000										
PCN O	5	-088	-228	-103	-140	1000									
PCN E	6	-003	220	041	042	-319	1000								
C FLU	7	219	123	173	211	424	090	1000							
C FLE	8	243	199	220	237	-119	109	550	1000						
C O	9	240	135	179	248	-010	123	865	635	1000					
C E	10	147	116	118	164	024	211	812	656	879	1000				
PCL FLU	11.	213	183	218	244	-268	125	097	137	126	011	1000			
PCL FLE	12	103	128	103	139	-086	-069	110	029	132	148	196	1000		
PCL O	13	070	063	009	102	010	-018	035	018	110	069	164	-037	1000	
PCL E	14	119	049	076	101	-005	-004	129	159	168	163	055	-135	118	1000

*Decimal Points Omitted

CORRELATION MATRIX PIAGETIAN TASKS*

VARIABLE		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15
TIME	1	1000														
COUN.	2	131	1000													
L I.	3	118	038	1000												
T B	4	-116	147	-074	1000											
CVL	5	-131	-205	156	-011	1000										
CVP	6	-147	106	-100	072	-244	1000									
INS	7	-078	-086	208	-273	085	090	1000								
NUM	8	-013	-056	039	193	036	-305	008	1000							
C L	9	-008	-116	115	052	137	-028	-121	-196	1000						
S H	10	-086	-221	070	-134	-024	-013	-289	-124	-190	1000					
C A	11	-093	-201	008	-018	-327	-026	-045	144	100	036	1000				
T/P	12	054	035	034	281	-046	155	353	129	106	136	-067	1000			
FHA	13	001	180	033	-040	-133	218	093	017	-000	189	303	159	1000		
FHB	14	-059	107	-013	-157	168	-198	-042	-061	017	027	150	145	342	1000	
FF	15	-008	271	-063	-111	106	393	120	061	091	258	209	165	519	464	1000

*Decimal Points Omitted



CORRELATION MATRIX

TORRANCE FLEXIBILITIES - INHELDER PIAGET*

VARIABLE		1	2	3	4	5	6
U U FLE	1	1000					
C FLE	2	133	1000				
PCL FLE	3	155	012	1000			
F HA	4	507	509	093	1000		
F HB	5	287	408	068	342	1000	
F F	6	582	573	437	519	464	1000

*Decimal Point Omitted

CORRELATION MATRIX: FINAL BATTERY*

VARIABLE		1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
AGE	1	1000															
DCC	2	131	1000														
RCPM	3	194	137	1000													
HC	4	204	106	385	1000												
OU	5	076	138	483	305	1000											
ONU	6	107	068	324	388	390	1000										
CUU	7	007	067	126	209	348	319	1000									
CPCN	8	056	028	178	110	050	092	-059	1000								
C C	9	173	030	148	143	121	162	218	220	1000							
CPCL	10	019	253	117	045	304	096	097	147	214	1000						
L I	11	-202	-032	119	-084	060	069	-117	073	002	069	1000					
R B	12	148	133	415	789	335	435	186	083	129	123	-074	1000				
CLA	13	065	001	205	086	137	-119	159	-011	-033	006	-165	020	1000			
N	14	094	033	034	033	148	170	175	076	218	188	038	138	175	1000		
DEC	15	133	048	175	056	194	019	221	063	267	036	-013	131	070	053	1000	
R A	16	107	159	097	162	274	292	495	037	420	128	-054	164	136	274	390	1000

*Decimal Points Omitted